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FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NORTHWEST REGION. PACIFIC NORTHWEST WATER LABORATORY

PLYWOOD PLANT GLUE WASTES DISPOSAL:

PROGRESS REPORT

February 1968

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CLEAN WATER

PROGRESS REPORT

PLYWOOD PLANT GLUE WASTE DISPOSAL

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U. S. Department of the Interior
Federal Water Pollution Control Administration
Northwest Region
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ABSTRACT

In the States of Oregon, Washington, Idaho, Montana, and California, 158 plywood plants generate an estimated 6.2 million gallons of waste per day from the cleanup of glue mixing equipment and glue spreaders. The waste is toxic and high in pollutional strength. Treatment of these glue wastes varies from plant to plant but generally consists only of solids separation or the removal of suspended matter. Further investigations are needed to determine which treatment methods will solve the pollution problems caused by the discharge of these wastes.

TABLE OF CONTENTS

Page

I. INTRODUCTION

A. Problem 1
B. Objectives 2
C. Authority 2
D. Acknowledgments 2

II. SUMMARY

A. Findings 4
B. Conclusions 4

III. PLANT SURVEY 5

IV. PLYWOOD PLANT CHARACTERISTICS

A. Locations and Number 8
B. Production 8
C. Operations 11

V. WASTE CHARACTERISTICS

A. Waste Quantity 18
B. Waste Quality 28

VI. DISPOSAL OF WASTE

A. Methods in Use 33
B. Incineration of Waste 36

VII. PROPOSED STUDIES 40

VIII. SELECTED REFERENCES 41

IX. APPENDIX

A. Definition of Terms 43
B. Plywood Plant Locations 47

LIST OF FIGURES

No.		Page
1	Plywood Plant Flow Diagram	12
2	Average Glue Waste Flows (Plant 1)	20
3	Daily Average Glue Waste Flows (Plant 2)	22
4	Daily Average Glue Waste Flows (Plant 3)	23
5	Daily Average Glue Waste Flows (Plant 4)	24

LIST OF TABLES

No.		Page
1	Number of Plants by Types of Plywood	6
2	1966 Plant Production by Type and Grade of Plants Surveyed	7
3	Number and Percentage of Plants Surveyed	9
4	1966 Plant Production by Types of Plywood	10
5	Number of Glue Spreaders for Plants Surveyed . . .	13
6	Number of Spreader Shifts for Plants Surveyed . . .	14
7	Green Ends, Cold Decks, and Log Ponds	16
8	Number and Size of Log Ponds at Plants Surveyed . .	17
9	Characteristics of Plants Used in Discharge Study .	19
10	Glue Waste Discharge Measurements	25
11	Ingredients of Typical Exterior and Interior Glue Mixes	29
12	Chemical Analysis of Plywood Glue	31
13	Disposal Methods of Plants Surveyed	34
14	Chemical Analysis of Settled Effluent	35
15	Incineration Test of Exterior and Interior Glue .	38

PROGRESS REPORT
PLYWOOD PLANT GLUE WASTE DISPOSAL

I. INTRODUCTION

A. Problem

The cleanup of glue spreaders at 158 plywood mills throughout the study area produces a waste that is high in pollutional strength even though volumes are quite low. At the present time the State of Oregon rates this waste as their primary pollution problem based on the number of complaints received.

The glues used in the plywood industry are of three basic types: the blood soya variety used for interior grade plywood; the phenolic formaldehyde variety used for exterior grade plywood; and a urea formaldehyde glue used for hardwood paneling. Each type presents its own problem and combinations of two or more types of glue present additional and more complicated problems.

The blood soya glues produce an alkaline waste with a high oxygen demand. Coagulation of the glue solids may cause large masses of solids resulting in sewer stoppage. The waste also supports the growth of Sphaerotilus sp.

Phenolic formaldehyde glues produce a toxic waste which is alkaline. The waste from this glue also creates color, taste, and odor problems.

The urea formaldehyde glues also produce a toxic waste, but it is acidic. These glues are used for less than 8 percent of the plywood production in the study area. For this reason, the majority of work has been done with the interior and exterior glues.

B. Objectives

This study is to determine the magnitude and extent of the problem created by the disposal of glue wastes, review the characteristics of plywood glue wastes, and recommend methods of treatment for these wastes. The study area includes the States of Oregon, Washington, Montana, Idaho, and California. Basic information on plywood plants was collected from plants in all five States while field work has been confined to plants in Oregon that are representative of those in the industry. This progress report covers the preliminary phases of the project. A final report will be issued later covering the entire project.

C. Authority

The Pacific Northwest Water Laboratory of the Federal Water Pollution Control Administration, Northwest Region, was requested by the Oregon State Sanitary Authority, letter dated January 19, 1966, to study methods for disposing of glue wastes from plywood plants. The Federal authorization for this study was from the Federal Water Pollution Control Act, as amended.

D. Acknowledgments

Acknowledgment is given the American Plywood Association for

their valuable assistance in conducting the survey.

Special thanks to the Borden Chemical Company at Springfield, Oregon, for their donation of glue ingredients and their assistance in explaining and defining techniques involved in the preparation of the mixes.

Thanks are due to the personnel of the many plants visited. Their interest and cooperation is appreciated.

II. SUMMARY

A. Findings

1. Some 158 plywood plants in the study area generate an estimated 6.2 million gallons of waste per day from the cleanup of glue spreaders and glue mixing equipment.

2. Water usage at plants varies greatly with no apparent relationship to amount or type of plywood produced.

3. Both exterior and interior grade glues exhibit high pH and COD. The exterior grade glue is high in phenol but low in nitrogen and phosphorus content.

4. Interior and exterior glues each contribute approximately 50 percent of total waste based on production figures.

5. Most plywood plants utilize some sort of settling tank which removes the wood chips and some of the glue solids, but some plants still dump raw waste into rivers, the ocean, and other receiving bodies of water.

6. Glue solids can be burned at high temperatures with small percentages of ash being produced.

B. Conclusions

1. Water usage at most plants far exceeds that required to wash down the spreaders and glue-mixing equipment.

2. Proper maintenance of settling tanks and ponds is neglected until they become inoperative. This lack of maintenance leads to low efficiencies.

III. PLANT SURVEY

Plywood plants vary with respect to many parameters such as size, type of waste generated, and waste disposal methods. To gain an understanding of the plywood industry two methods were employed. The first involved personal visits to 50 plants; all in the State of Oregon. The second method consisted of obtaining from the American Plywood Association (A.P.A.) the information they had collected from a survey of their plants. This survey was concerned with production, operations, waste generation, and disposal practices.

To obtain a good response, the A.P.A. had their plant supervisors personally fill out a questionnaire when they visited each plant in their district. This method gave a 100 percent return for the plants belonging to the A.P.A. From the results listed in Table 1 and Table 2, it can be seen that the survey represented about 67 percent of the plants and 70 percent of the production in the study area; this appears to have been a representative sample of the industry.

TABLE 1

Number of Plants by Types of Plywood[a/]

State	Softwood Plants	Hardwood Plants	Mixed Plants	Total Plants
California	17	4	1	22
Idaho	4	0	0	4
Montana	6	0	0	6
Oregon	84	2	6	92
Washington	22	2	10	34
Totals	133	8	17	158

[a/] 1967 Plywood and Board Products Directory

TABLE 2

1966 Plant Production, by Type and Grade, of Plants Surveyed[a/]

State	Softwood Production (Sq.Ft. 3/8" Basis) Interior Grade	Softwood Production (Sq.Ft. 3/8" Basis) Exterior Grade	Hardwood Production (Sq.Ft. 3/8" Basis)	Total Production (Sq.Ft. 3/8" Basis)
California	345,480,000	230,820,000	---	576,300,000
Idaho	112,200,000	27,000,000	---	139,200,000
Montana	274,764,000	118,836,000	---	393,600,000
Oregon	2,760,048,000	2,874,252,000	11,460,000	5,645,760,000
Washington	889,272,000	1,165,800,000	310,128,000	2,365,200,000
Totals	4,381,764,000	4,416,708,000	321,588,000	9,120,060,000
%	48.0	48.4	3.6	100.0

[a/]A.P.A. Survey, 1967

IV. PLYWOOD PLANT CHARACTERISTICS

A. Location and Number

The location of the 158 plywood plants in the five-state study area is shown on Plate 1 in Appendix B. The plants are concentrated in the Willamette and Rogue River Valleys in Oregon and the Puget Sound area in Washington. Table 3 shows the distribution by state of the 158 plants. As can be seen, Oregon has 92 plants or approximately 58 percent of the total. Table 1 gives the breakdown by type of plywood produced by the plants surveyed. Comparison of the tables shows that a good cross-section was obtained by the survey.

B. Production

Plywood production for 1966, which was a normal year, is given in Table 4. These data give the hardwood and softwood production by states and show that in the study area the softwood makes up 92.1 percent of the total. The production in the State of Oregon in 1966 was 64 percent of the total for the five states in the study area.

Table 2 gives the 1966 production for the plants surveyed. In this table, the softwood production is further divided into interior and exterior grades of plywood. The survey shows that the total production of interior and exterior grades is very similar, being 48.0 percent and 48.4 percent, respectively. Hardwood plywood production accounts for the remaining 3.6 percent. Since each type of plywood uses a different type of glue, these data indicate the relative amounts of the glues used.

TABLE 3

Number and Percentage of Plants Surveyed[a/]

State	Number Plants	Number Plants Surveyed	% Plants Surveyed
California	22	11	50
Idaho	4	2	50
Montana	6	4	67
Oregon	92	59	64
Washington	34	30	88
Totals	158	106	67

[a/]A.P.A. Survey, 1967

TABLE 4

1966 Plant Production by Types of Plywood[a/]

State	Softwood Production (Sq.Ft. 3/8" Basis)	Hardwood Production (Sq.Ft. 3/8" Basis)	Total Production (Sq.Ft. 3/8" Basis)
California	1,277,000,000	115,500,000	1,392,500,000
Idaho	293,100,000	---	293,100,000
Montana	456,000,000	---	456,000,000
Oregon	7,948,350,000	499,450,000	8,447,800,000
Washington	2,150,600,000	427,500,000	2,578,100,000
Totals	12,125,050,000	1,042,450,000	13,167,500,000
%	92.1	7.9	

[a/] 1967 Plywood and Board Products Directory

C. Operations

To help understand the plywood operations, a flow chart of a complete plant is shown in Figure 1. This flow chart also indicates sources of solid and liquid wastes.

1. Green End

The green end of a plant involves the storage and handling of logs through the process of turning them into veneer. Storage of logs may be through the use of a log pond, cold decks, or a combination of both. Log ponds at plywood plants usually serve as a disposal site for the glue wastes. This rids the plant of the glue waste but usually complicates the pollutional problems caused by the log storage itself. Cold decking also causes some pollution problems; water sprayed over the logs to keep them from checking usually finds its way into the log pond or to another receiving body of water. Table 5 presents data on green ends, log ponds, and cold decks. Of the plants surveyed, 82.1 percent have green ends. Of these with green ends, 63.2 percent have log ponds and 59.4 percent have cold decks. Table 6 presents more detailed information on the log ponds. The average size log pond for the plants surveyed was 17 acres with a range from one-half to 100 acres.

2. Gluing

The first source of glue waste comes from the washdown of kettles and equipment used to mix the glue ingredients. A typical plant, which produces 100,000,000 square feet of plywood per year, approximately 50 percent exterior grade and 50 percent interior

PLYWOOD PLANT FLOW DIAGRAM

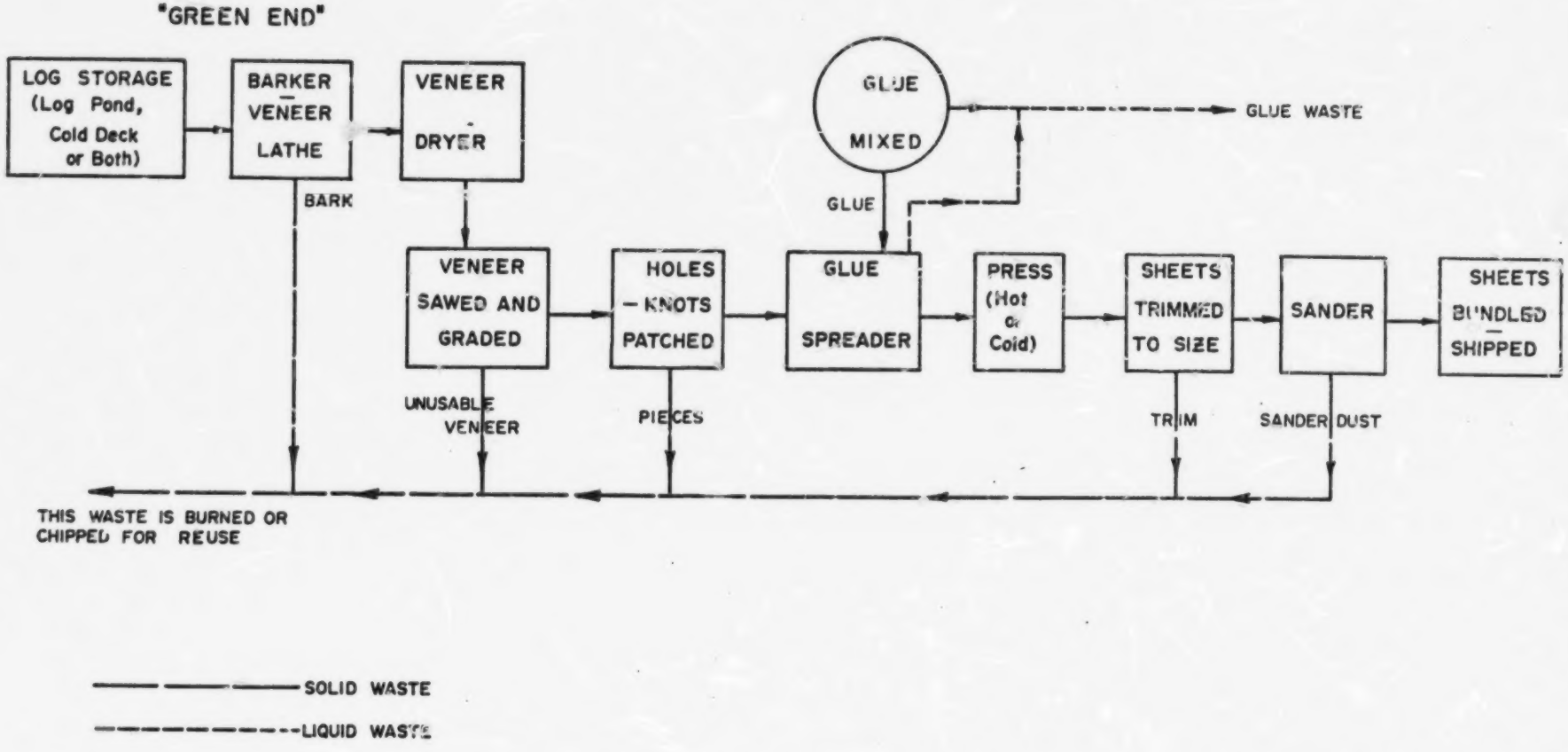


TABLE 5

Green Ends, Cold Decks, and Log Ponds[a/]

State	Plants Surveyed with Green Ends (%)	Plants Surveyed with Cold Decks (%)	Plants Surveyed with Log Ponds (%)
California	90.9	72.7	27.3
Idaho	100.0	100.0	0.0
Montana	100.0	100.0	16.7
Oregon	83.1	57.6	72.9
Washington	73.3	50.0	56.7
Average for 5 States	82.1	59.4	63.2

[a/] A.P.A. Survey, 1967

TABLE 6

Number and Size of Log Ponds at Plants Surveyed[a/]

State	Number of Plants with Ponds	Total Size of Ponds (Acres)	Avg. Size of Ponds (Acres)	Max. Size of Ponds (Acres)	Min. Size of Ponds (Acres)
California	6	88.5	14.8	30.0	2.5
Idaho	0	0.0	0.0	0.0	0.0
Montana	1	7.5	7.5	7.5	7.5
Oregon	43	865.5	20.1	100.0	1.5
Washington	17	169.5	10.0	75.0	5
Average for 5 States	67	1,131.0	16.9		
Maximum Size for 5 States				100.0	
Minimum Size for 5 States					.5

[a/] A.P.A. Survey, 1967

grade, makes about 11 batches per day of interior glue and 9 batches per day of exterior glue. This amounts to approximately 400,000 pounds of exterior and 350,000 pounds of interior glue per month. The mixing equipment may not always be washed between batches, but when it is washed only a small amount of water is used. Thus, the waste volume from this phase of the operation is a small but highly concentrated part of the total waste.

The second source of glue waste is from the spreaders themselves. Table 7 gives data on the number of spreaders in the plants surveyed. As can be seen, the average plant has approximately three spreaders with a range from one to nine. Of more interest is the number of spreader shifts per day. Table 8 contains data on spreader shifts for the surveyed plants. The average plant has slightly over six spreader shifts per day with a range from one to twenty. These spreaders are usually washed down once per shift when interior glue is used and at least once per day for exterior glue. The difference is due to the fact that the interior glues have a pot life of 6 to 8 hours whereas the exterior glue lasts almost indefinitely. The accumulation of wood chips in the pans of the spreaders usually necessitates cleaning the exterior glue spreaders at least once per day.

TABLE 7

Number of Glue Spreaders for Plants Surveyed[a/]

State	Number	Average/ Plant	Max./ Plant	Min./ Plant
California	24	2.2	4	1
Idaho	3	1.5	2	1
Montana	10	2.5	4	2
Oregon	179	3.0	9	1
Washington	94	3.1	6	1
Total	310			
Average for 5 States		2.9		
Maximum for 5 States			9	
Minimum for 5 States				1

[a/] A.P.A. Survey, 1967

TABLE 8

Number of Spreader Shifts for Plants Surveyed[a/]

State	Total Number	Average/ Plant	Max./ Plant	Min./ Plant
California	42	3.8	7	1
Idaho	8	2.0	5	3
Montana	25	6.3	11	4
Oregon	406	6.9	20	2
Washington	185	6.2	16	1
Total	666			
Average for 5 States		6.3		
Maximum for 5 States			20	
Minimum for 5 States				1

[a/] A.P.A. Survey, 1967

V. WASTE CHARACTERISTICS

A. Waste Quantity

1. Measured Waste Discharges

Waste flows were measured at four plants over periods ranging from 6 weeks to several months. A different scheme was used at each plant for these measurements due to equipment availability and accessibility to the waste stream. The plants where flows were measured will be referred to by number. Pertinent data on the four plants are in Table 9.

At Plant Number 1, a water meter was placed in the wash-water line adjacent to one of the four glue spreaders. This meter was read at various time intervals over a 7-month period. The meter readings were multiplied by four, and the average flows were computed. Figure 2 shows these flows for the 7-month period. The average flow for the 7-month period was 12.9 gpm, and the average flow for the working days in the period was 18.2 gpm.

At Plant Number 2, a 45-degree V-notch weir and water level recorder were installed in a ditch between the plant and the settling pond. This proved to be a bad arrangement as the weir was soon plugged with glue and wood chips. The weir was removed and an alternate plan was sought. At this plant, the settling pond effluent was pumped into the log pond. The pump was controlled by a set of probes. The recorder was placed on the pond. The pond area was measured and

TABLE 9

Characteristics of Plants Used in Discharge Study

Plant Number	1966 Production[a/] (Sq.Ft.3/8" Basis)	Exterior Grade (%)	Interior Grade (%)	Number of Spreaders	Spreader Shifts Per Day	Days Worked Per Week
1	100,000,000	50	50	4	8	5
2	135,000,000	0	100	3	9	5
3	100,000,000	25	75	4	9	5
4	70,000,000	75	25	2	6	5

[a/] 1967 Plywood and Board Products Directory

AVERAGE GLUE WASTE FLOWS
(PLANT 1)

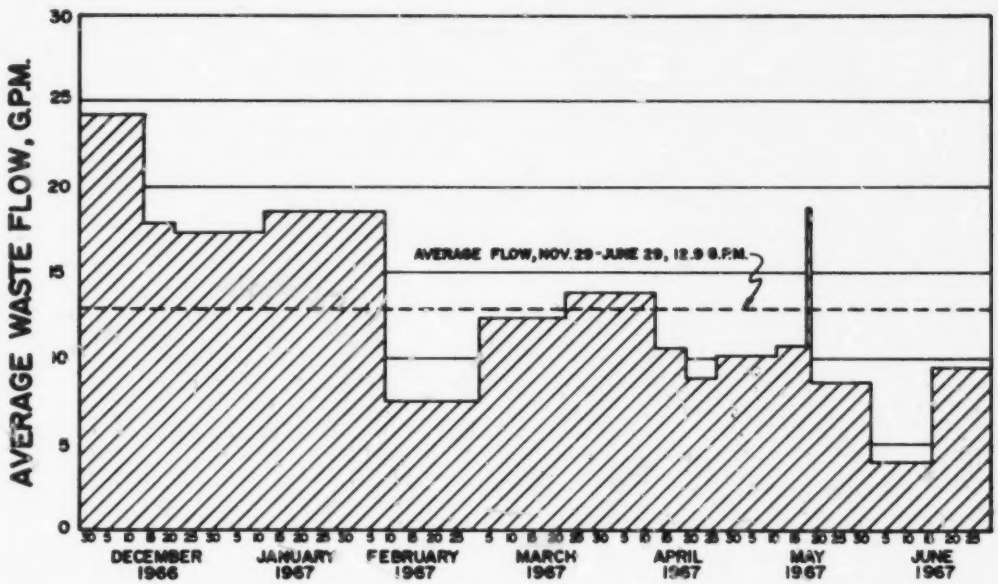


FIGURE 2

the flow was determined. This set up was used for 7 weeks and proved to be the easiest to maintain. Figure 3 shows the daily average flows for the period. The average flow for the 7 weeks was 24.4 gpm and the average flow for the working days was 30.2 gpm.

At Plant Number 3, a 60-degree V-notch weir and level recorder were installed in a ditch located downstream from the plant's settling tank. This setup was used for 6 weeks and required only minor maintenance. Figure 4 shows the daily average flows for the period. The average flow for the period was 17.9 gpm and the average flow for the working days was 21.6 gpm.

At Plant Number 4, a 16-inch rectangular weir and level recorder were installed in the last compartment of the plant's settling tank. This setup was used for 6 weeks. Figure 5 shows the daily average flows for the period. The average flow for the period was 53.2 gpm and the average flow for the working days was 54.0 gpm.

Table 10 compiles the flow data for the four plants. As can be seen, the average flows vary widely. This variance should be a result of the spreader shifts per day and the types of glue used. Plant Number 4, with the fewest spreader shifts per day and the highest percentage of exterior grade production, should have the smallest flow but as can be seen it is much higher than the other three. At Plant Number 4 there is only a small difference between amount of water used on working and nonworking days further indicating water is being used when spreaders are not being washed down.

DAILY AVERAGE GLUE WASTE FLOWS (PLANT 2)

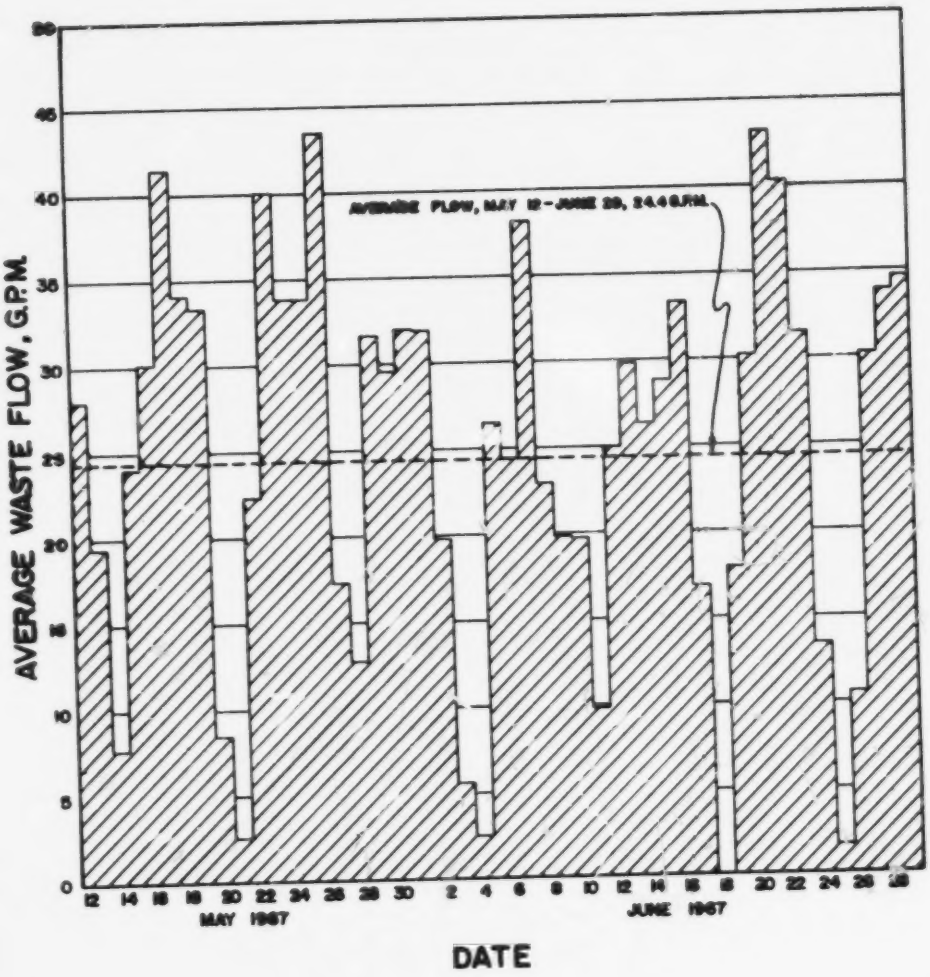


FIGURE 3

DAILY AVERAGE GLUE WASTE FLOWS (PLANT 3)

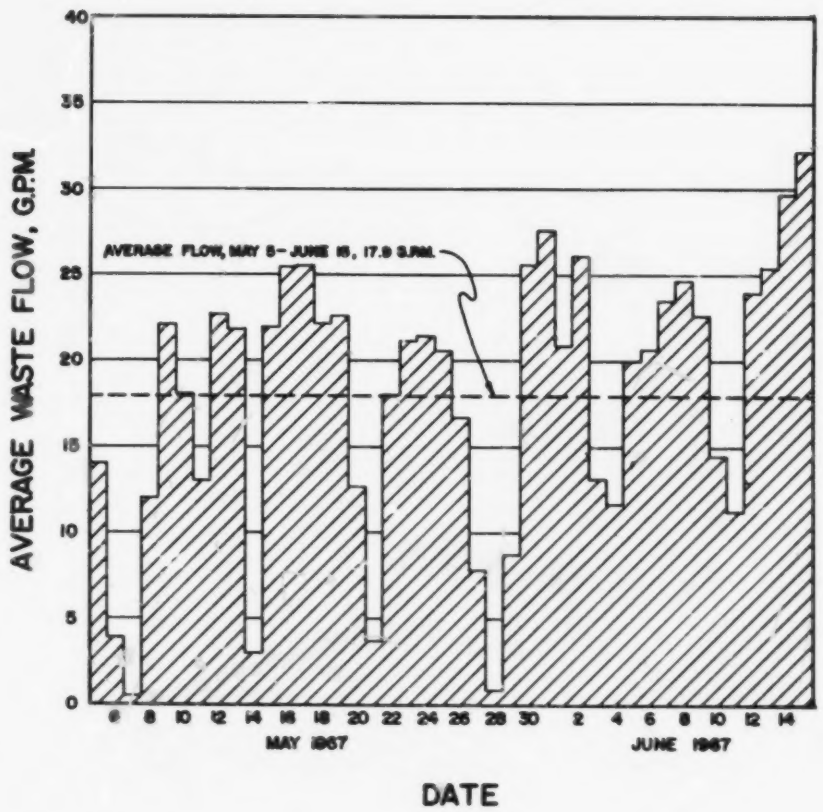


FIGURE 4

DAILY AVERAGE GLUE WASTE FLOWS (PLANT 4)

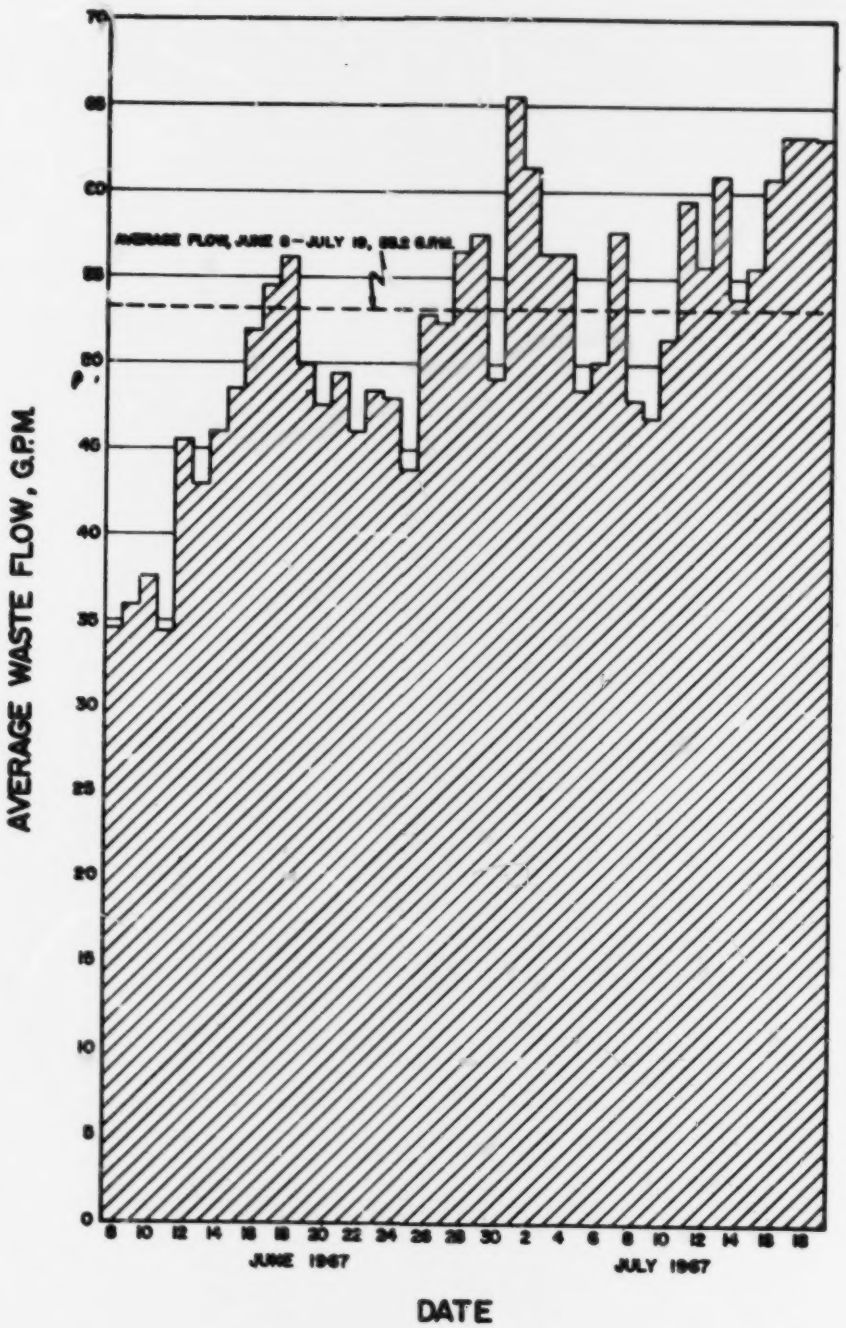


FIGURE 5

TABLE 10

Glue Waste Discharge Measurements

Plant[a/] Number	Days Measured	Average Discharge for Days Measured (gpm)	Average Discharge Working Days (gpm)	Average Daily Maximum Discharge (% Avg Discharge)	Average Daily Minimum Discharge (% Avg Discharge)
1	212	12.9	18.2	--	--
2	49	24.4	30.2	--	--
3	42	17.9	21.6	211	53
4	42	53.2	54.0	215	67

[a/] See Table 9 for plant descriptions

The flow from Plant Number 1 was much lower than the other three. This may be due to the manner by which the flow was calculated. Here, actual amounts of water used for washdown were measured, eliminating any other discharges which may get into the waste stream further down the line such as the washdown water from the glue mixing area.

On two plants the daily maximum and minimum flows were recorded. The average is shown in Table 10. These are shown as a percentage of the average flow. The maximum for the two plants averaged 213 percent while the minimum was 60 percent.

The average discharge for the four plants was 27.1 gpm. This is about 39,000 gpd. When multiplied by the 158 plants in the study area, it results in a discharge of 6.2 million gallons per day of glue waste.

In conclusion, it can be seen that under present conditions of inexpensive water and little concern over the destination and pollutional effects of the waste, the flow from different plants will vary markedly depending on plant practices.

2. Calculated Waste Discharges

Two spreader washdowns have been observed. Both of these took place at Plant Number 1 where a water meter had been installed in the wash-water line. The first washdown required 210 gallons, took approximately 35 minutes, and resulted in an average discharge of 6 gpm. The second washdown measured 250 gallons, took approximately 35 minutes, and resulted in an average discharge of 7 gpm.

For this calculation assume that 250 gallons at 7 gpm is needed to wash down a spreader. To flush out lines or troughs, an additional 10 minutes at 7 gpm is added, giving a total of 70 gallons for flushing. This gives a total of 320 gallons for each washdown. The average interior plywood plant with six spreader shifts and a washdown at the end of each shift would generate 1,920 gallons of waste per day. To this should be added the contribution from the washdown of glue mixing equipment. A plant making 10 batches of glue per day and washing down their equipment after each batch should add approximately 300-500 gpd of waste. The total glue waste discharge should then be around 2300 gpd per plant. This is considerably less than the 18,500 to 76,500 gallons measured at Plants 1-4. This great difference can be traced to the fact that water is allowed to run in the waste lines when glue is not being washed off equipment. This practice has been followed for one or more of the following reasons. First, some plant personnel feel that by diluting the glue waste their pollution problems will be reduced. Second, lines have become plugged on occasion and water is kept running in an effort to prevent this. Third, forgetfulness and poor plant practices account for the excess amounts of water consumed.

It is concluded that glue waste discharges could and should be reduced considerably. This could easily be done through better in-plant practices and through the development of new techniques such as the use of steam instead of water for cleaning

the metal parts of equipment. Surely, if a disposal method such as incineration is to be used, the waste should be concentrated as much as possible.

The problem of plugged lines could possibly be solved by using better line flushing techniques, minimizing waste line lengths, by using teflon coated pipes or a combination of these. If biological treatment is to be employed, some dilution of waste beyond the quantities calculated may be needed to reduce the effects of toxic substance on biological organisms. This problem will be studied further in connection with activated sludge pilot plant work.

B. Waste Quality

1. Chemical Investigations

Many different glue formulas are used by the plants in the study area. However, the glues vary only slightly with respect to their actual ingredients. Table 11 lists the ingredients of typical interior and exterior glue mixes. The pentachlorophenol or phenolic formaldehyde resin listed under interior glue is added only when a toxic mix is required. This toxic mix makes the glue more resistant to biological degradation.

Because all glues could not be chemically analyzed, typical exterior and interior glues were chosen. These were Borden's Cascophen 31[a/] exterior glue and Borden's Casco S-230[a/]

[a/] Use of product and company names is for identification only and does not constitute endorsement by the Department of the Interior.

TABLE 11

Ingredients of Typical Exterior and Interior Glue Mixes

Exterior

Water
Furafil[a/]
Wheat flour
Phenolic formaldehyde resin
Caustic soda
Soda ash

Interior

Water
Dried blood
Soya flour
Lime
Sodium silicate
Caustic soda
Formaldehyde doner for thickening
Pentachlorophenol[b/]
Phenolic formaldehyde resin[b/]

[a/] Residue from furfural extraction of corn cobs and oat hulls

[b/] May be added to produce a toxic glue

interior glue. The Casco S-230 mix contains neither pentachlorophenol nor phenolic formaldehyde resin. The ingredients of these glues were obtained from the producing company and the glues were mixed in the laboratory. These prepared glues were then chemically analyzed. Table 12 lists the results of these analyses. As can be seen, the COD of the exterior glue is much greater than that of the interior glue. The levels of total phosphates and total kjeldahl nitrogen, however, are much higher in the interior glue. These low levels of phosphate and total kjeldahl nitrogen in the exterior glues may make it necessary to add nutrients for biological treatment. The phenol concentration of the exterior glue is much greater than that of the interior glue. While the phenol concentrations are quite high (514 mg/kg) they still are in the range of 500 mg/l found by McKinney et al to be biologically treatable with proper acclimation.(1)

2. Biological Investigations

a. Stream Survey

Biological investigations of a small creek in Western Oregon were undertaken to determine the effects of plywood glue wastes on the ecology of a small stream. This creek receives both interior and exterior plywood glue wastes from Plant Number 1.[a/]

Ten sampling stations were established on the creek. The aquatic community is being sampled routinely through the

[a/] Information regarding this plant can be found in Table 9.

TABLE 12

Chemical Analysis of Plywood Glue

Analysis and Units	Exterior Glue[a/]	Interior Glue[b/]
COD, mg/kg	653,000	176,500
TOC, mg/kg	176,000	52,000
Total Phosphate, mg/kg as P	120	260
Total Kjeldahl Nitrogen, mg/kg as N	1,200	12,000
Phenols, µg/kg	514,000	1,810
Suspended Solids, mg/kg	92,000	59,000
Dissolved Solids, mg/kg	305,000	117,500
Total Solids, mg/kg	397,000	176,500
Total Volatile Suspended Solids, mg/kg	84,000	34,000
Total Volatile Solids, mg/kg	171,500	137,000

[a/] Borden's Cascophen 31 which is similar to Borden's Cascophen 382
[b/] Borden's Casco S-230

collection of bottom-dwelling animals, phytoplankton, and attached algae. Artificial substrates for the collection of bottom animals and diatoms were also installed and are being serviced at scheduled intervals.

Preliminary results from samples that have already been collected indicate a classical picture of river pollution. The creek supports a well balanced community of aquatic organisms upstream from the waste outfall and exhibits extremely degraded conditions downstream. Pollution-tolerant organisms are in abundance below the outfall along with large amounts of Sphaerotilus.

Studies of this creek are valuable in showing dramatic changes in the stream environment due to plywood glue wastes. However, the large volume of wastes and the normally low stream flow coupled with a marshy drainage area in the downstream reaches of the creek, make it difficult to evaluate recovery from the glue wastes.

b. Bioassays

Toxicity bioassays run in accordance with Standard Methods are being conducted to evaluate the relative acute toxicity of plywood glue. A series of bioassays, using guppies as test organisms, were conducted on both interior and exterior glues. The test solutions were renewed daily to lessen the effects of deoxygenation and detoxification. Preliminary results indicate the Cascophen 382, an exterior glue, is about four times as toxic as Casco S-230, an interior glue. Median tolerance limits for 96 hours for Cascophen 382 ranged from 830 to 1200 mg/l while Casco S-230 ranged from 4200 to 4800 mg/l.

VI. DISPOSAL OF WASTE

A. Methods in Use

Many different disposal methods for glue waste are being used at the present time. These methods vary from no treatment to systems involving municipal treatment plants. Table 13 lists 23 different schemes used by the 106 plants surveyed. As can be seen, 77 plants employ some type of settling tank or pond. The settling tanks commonly consist of one or more 1,000-gallon septic tanks. These settling devices remove some of the glue solids and the wood chips. Table 14 lists the chemical analyses of the settled effluent for three of the plants used in the discharge survey.[a/] Comparison of Table 12 and Table 14 shows a significant increase in the dissolved solids/suspended solids ratio after the settling operation, indicating a reduction of suspended solids. A similar comparison also shows little reduction in phenols, phosphates, and total kjeldahl nitrogen.

The removal of suspended solids is further evidenced by the filling of settling devices, necessitating their periodic clean out. This clean out is needed every 1 to 3 months depending on the size of the tank, number of washdowns, and types of glues used. In these tanks and ponds, lack of proper maintenance leads to poor efficiencies and subsequent problems. Usually, these tanks are not cleaned until

[a/] Information regarding the three plants can be found in Table 9.

TABLE 13

Disposal Methods of Plants in Survey

Disposal System	Number of Plants Using System					
	California	Idaho	Montana	Oregon	Washington	Total
Field Spreading	1			2		3
Log Pond (N.O.)[a]	1					1
Log Pond, Field Spreading	1					1
Log Pond, S.L.R.O.[b]	1			4		5
Municipal Sewer		1		5	1	7
Settling Pond (N.O.)	1		1	5	1	8
Settling Pond, Log Pond (N.O.)				3		3
Settling Pond, S.L.R.O.				1	1	2
Settling Pond, Waste Burner				1		1
Settling Tank, (Further Disposal Unknown)			2	8	4	14
Settling Tank, Field Spreading	2			2	3	7
Settling Tank, Log Pond (N.O.)				4	1	5
Settling Tank, Log Pond, Field Spreading				1		1
Settling Tank, Log Pond, S.L.R.O	1			3		4
Settling Tank, Municipal Sewer			1	4		5
Settling Tank, Settling Pond (N.O.)					1	1
Settling Tank, Settling Pond, Field Spreading				1		1
Settling Tank, Settling Pond, Slough		1				1
Settling Tank, Settling Pond, S.L.R.O.	1			1		2
Settling Tank, S.L.R.O.				8	12	20
Settling Tank, Waste Burner				1	1	2
S.L.R.O.	2			4	5	11
Other[c]				1		1

[a] Nonoverflow

[b] Stream, Lake, River, or Ocean

[c] Waste is put in Drums and hauled to Land Disposal

TABLE 14

Chemical Analysis of Settled Effluent

Analysis & Units	#2 [a] Plant	#3 [b] Plant	#4 [c] Plant
pH	11.6	9.4	10.8
COD, mg/l	1814	1917	1621
TOC, mg/l	772	723	540
Total Phosphate, mg/l	15	9	12
Total Kjeldahl Nitrogen, mg/l	110	64	3
Phenol, µg/l	1667	1790	222
Suspended Solids, mg/l	148	356	330
Dissolved Solids, mg/l	1479	1458	790
Total Solids, mg/l	1627	1814	1120
Total Volatile Suspended Solids, mg/l	125	338	322
Total Volatile Solids, mg/l	1122	1267	919

[a] Average of 2 grab samples
[b] Average of 3, 24-hour composite samples
[c] Average of 2, 24-hour composite samples

they are completely filled, resulting in zero or even negative efficiencies.

Table 13 also shows that 18 plants employ some type of non-overflow system to dispose of their waste. In this type of system, rates of evaporation and infiltration exceed the waste input. Because of the plugging nature of glue solids, evaporation probably accounts for most of the moisture lost.

Twelve of the plants surveyed dispose of their waste in municipal treatment systems. High pH plus wood chips and glue solids cause some problems at these plants. Adjustment of pH and the use of settling tanks or ponds should make the waste amenable to conventional waste treatment The settling tank would also help damp out any slugs of toxic materials such as phenolic compounds which could upset the balance of a biological system.

Eleven of the plants listed in Table 13 dispose of their waste without treatment of any sort. The majority of these plants are located on large bodies of water such as Puget Sound, the Pacific Ocean, or the Columbia River.

B. Incineration of Waste

Due to the low volume of waste, the high organic content of the waste, and the availability of existing sources of heat, disposal by incineration offers a potential solution to the glue waste problem.

The survey of plants indicated that three plants at the present

time are using their waste burners to dispose of their glue waste. Realizing that waste burners burn rather inefficiently and that these metal "teepees" will be eliminated in the near future, some other source of heat is needed. One large corporation is considering the use of their Dutch ovens. Most plants have this type of device to generate heat. These ovens burn at temperatures from 1800-2000° F. If sander dust is burned, the temperature can go as high as 2500°F.

An ash test was made on samples of interior and exterior glue. These were run at the usual 600°C (1112°F) and at 1000°C (1832°F). The results of these tests are shown in Table 15 The tests indicate that at 1000°C (1832°F) very little ash would remain. The interior glue produced 4.12 and 23.40 percent ash, based on wet and dry weight, respectively, at 1000°C (1832°F). The exterior glue produced 6.12 and 15.76 percent ash, based on the wet and dry weight, respectively, at 1000°C (1832°F). A plant with three spreaders running six spreader shifts per day and washing down each shift would generate about 12 pounds of ash per day. This is a small percentage of the total ash produced in a furnace of this type.

The ash produced at 1000°C (1832°F) was tested to check whether it could be redissolved. A small portion was redissolved in H_2O while the majority could not be redissolved with either the strongest acids or bases.

TABLE 15

Incineration Test for Exterior and Interior Glue

Glue	Based on Wet Weight of Glue		Based on Dry Weight Glue Solids	
	% Ash @ 600°C	% Ash @ 1000°C	% Ash @ 600°C	% Ash @ 1000°C
Exterior[a/]	4.58	4.12	25.08	23.40
Interior[b/]	13.37	6.12	34.48	15.76

[a/] Borden's Cascophen 382

[b/] Borden's Casco S-230

One of the biggest problems in this method of disposal lies in transporting the glue waste from the spreader to the furnace. Maintenance of pumps and lines must be low. This problem will be investigated further as it will be important in many treatment schemes.

A third problem lies in a potential air pollution problem. Before incineration can be an accepted method of disposal, it must be shown that no harmful pollutants are given off from the burning of this waste.

VII. PROPOSED STUDIES

Future work on the project will be aimed at determining applicable treatment methods for plywood glue waste. Investigations will be made in regard to biological treatment, flocculation, sedimentation, and incineration.

Biological treatment will be studied by installing a mechanical aerator at a plant and by using some bench scale activated sludge units. These studies will be made with and without the use of pH control and additional of nutrients. The work with the bench scale units should give basic information on the treatability of the waste including some insight into the effect of glue waste on municipal treatment systems.

Flocculation and sedimentation studies will be made at the bench scale level. These investigations will include the use of flocculating agents such as alum, lime, ferric chloride, etc., plus the addition of polyelectrolytes. pH control will also be studied along with this phase of the project.

More work will be carried out on the process of incineration. This work will mainly concern problems associated with storage and handling of the waste from the time it leaves the spreader until it reaches the furnace. These problems could be acute as waste streams to be treated must be highly concentrated.

Water use and reuse will also be studied in conjunction with the above-mentioned treatment schemes.

VIII. SELECTED REFERENCES

1. Sawyer, Clair N., Chemistry for Sanitary Engineers, McGraw Hill, New York, 1960.

2. Anon., 1967 Plywood and Board Products Directory, Forest Industries, Portland, Oregon, 1967.

IX. APPENDIX

APPENDIX A

DEFINITION OF TERMS

DEFINITION OF TERMS

COD -- Chemical Oxygen Demand. A measure of the pollutional strength of sewage and industrial wastes which is based on fact that all organic compounds, with a few exceptions, can be oxidized to carbon dioxide and water. COD values give the amount of oxygen required to perform this oxidation.

Cold Deck -- A method of log storage where logs are stacked in piles and kept wet to prevent checking by use of sprinklers located on top of the stack.

Conductivity -- Referred to as specific conductance at a specified temperature (25°C). The opposite of resistance and used as a measure of the concentration of total ionized solids in water. Reported in micromohos (μMHOS).

Dissolved Solids -- Solids which are in solution.

Exterior Grade Plywood -- Plywood made with 100 percent waterproof glue and a high grade veneer.

gpm -- Gallons per minute.

Green End -- Portion of plant involving the storage and handling of logs through the process of turning them into veneer.

Interior Grade Plywood -- Plywood made with a moisture resistant (but not waterproof) glue.

μg/l -- micrograms per liter (1000 μg/l = 1 mg/l).

mg/l -- milligrams per liter (1000 mg/l = 1 gm/l).

mgd -- million gallons per day.

pH -- The negative log of the hydrogen ion concentration. The pH scale is usually represented as ranging from 0 to 14 with a pH of 7 representing neutrality. Acid conditions increase as pH values decrease and alkaline conditions increase as pH values increase.

Phenols -- (C_6H_5OH) The monohydroxy derivative of benzene, known as carbolic acid. Phenols are waste products of oil refineries, coke plants, and some chemical producing facilities. Phenols are used extensively in the synthesis of phenolic type resins. Concentration of phenols in the order of .01 to .1 mg/l are detectable by taste and odor tests.

Sphaerotilus sp. -- Slime-forming bacteria.

Spreader Shift -- One spreader running one shift (8 hours).

Suspended Solids -- Solids that either float on the surface or are in suspension in water, sewage, or other liquids.

TOC -- Total Organic Carbon. TOC is determined on a Beckman[a/] Carbonaceous Analyzer that catalytically oxidizes all organic carbon to carbon dioxide that is measured with an infrared analyzer.

Total Kjeldahl Nitrogen -- Organic nitrogen and nitrogen in the form of ammonia (NH_3). Does not include nitrogen in the form of nitrates (NO_3^-) and nitrites (NO_2^-). Nitrogen and phosphorus are nutrients necessary for maintaining biological growth.

[a/] Use of product and company is for identification only and does not constitute endorsement by the U. S. Department of the Interior.

Total Phosphate -- Phosphorus in organic and inorganic forms. Phosphorus and nitrogen are nutrients necessary for maintaining biological growth.

Total Solids -- The sum of the suspended and dissolved solids.

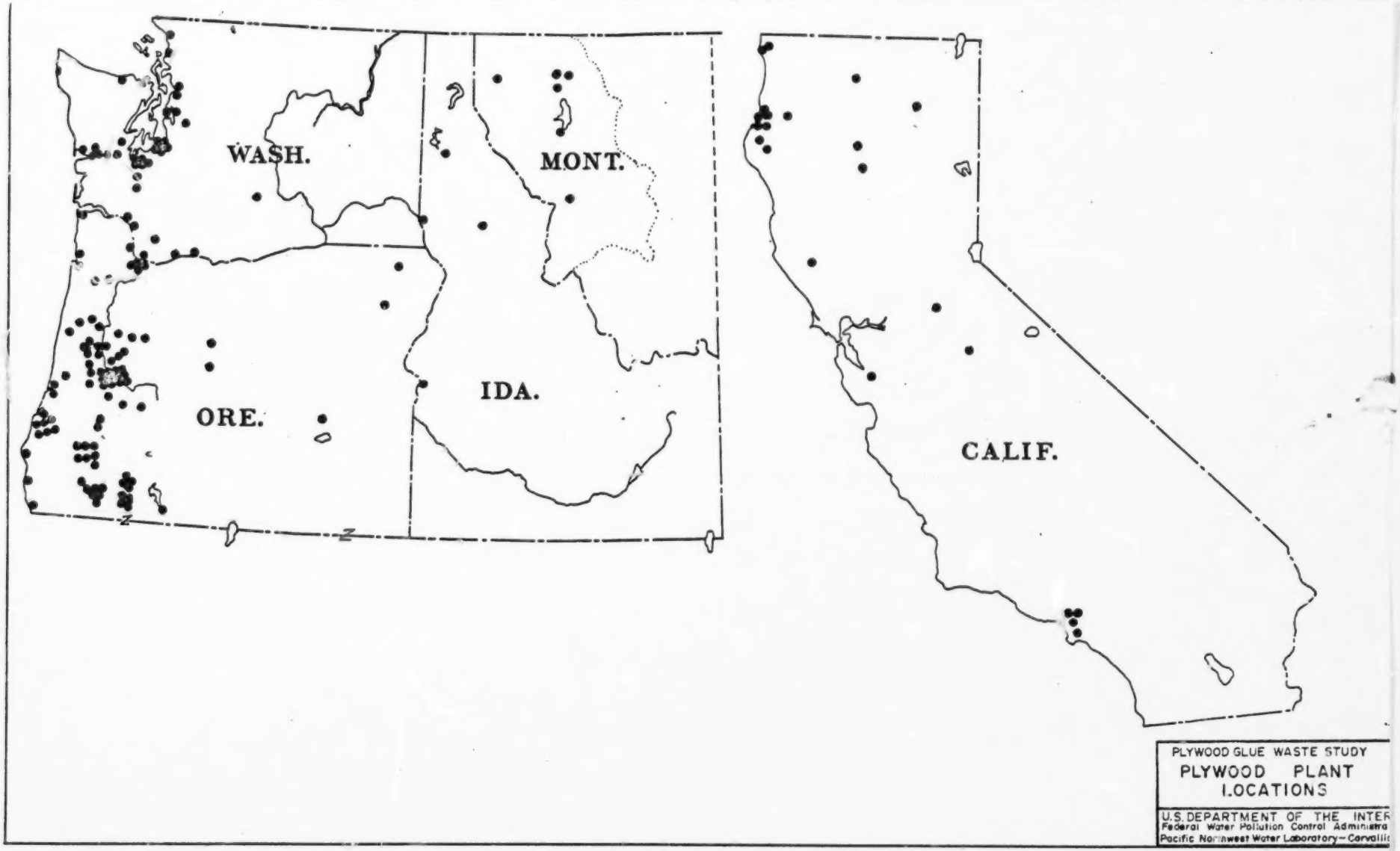
Total Volatile Solids -- The quantity of solids in water, sewage, or other liquids lost on ignition of the total solids at 600°C (1112°F).

Total Volatile Suspended Solids -- The quantity of solids in water, sewage, or other liquids lost on ignition of the suspended matter at 600°C (1112°F).

Veneer -- A thin sheet of wood turned off a log by a lathe and used in the production of plywood.

APPENDIX B

PLYWOOD PLANT LOCATIONS


WASH.
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PLYWOOD GLUE WASTE STUDY
PLYWOOD PLANT
LOCATIONS
U.S. DEPARTMENT OF THE INTER
Federal Water Pollution Control Administra
Pacific Northwest Water Laboratory – Corvallis